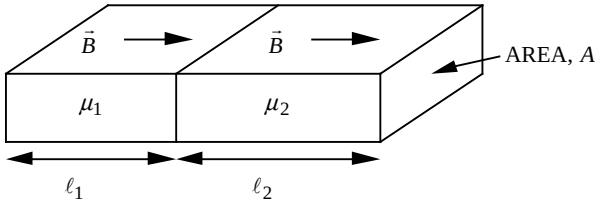
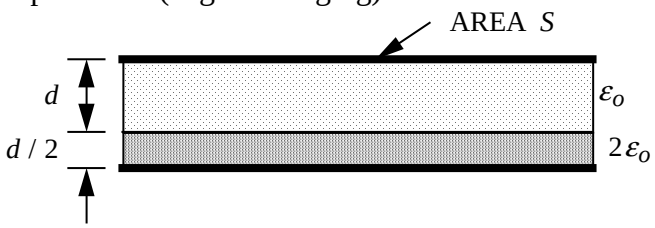
Sample Final Exam Problems (EC2600 and EO2652)

1. Two blocks of materials with permeabilities μ_1 and μ_2 are placed end to end. The magnetic flux density inside is uniform throughout and perpendicular to the ends. Find the total reluctance of the two blocks placed end to end in terms of the quantities shown.



2. A parallel plate capacitor has an area S with air and dielectric regions as shown. Find the capacitance (neglect fringing).



3. The magnetic field of a plane wave propagating through a certain nonmagnetic material ($\mu_r = 1$) is given by $\vec{H}(y,t) = \hat{z}\,50\cos(10^9 t - 5y)$ mA/m.

(a) What is the direction of propagation?

(b) Find the phase velocity, u_p.

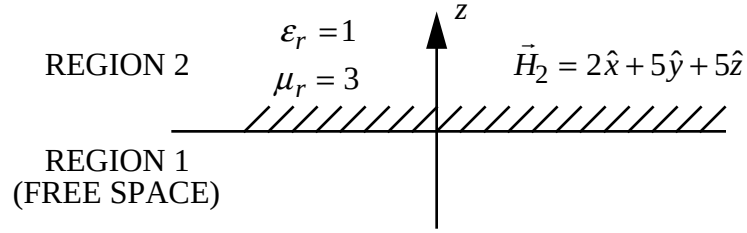
(c) Find the relative permittivity of the medium, ε_r.

(d) Find the wavelength in the medium, λ.

(e) Write an expression for the instantaneous electric field intensity, $\vec{E}(y,t)$.

4. Animal tissue has the constitutive parameters $\mu_r = 1$, $\varepsilon_r = 12$, and $\sigma = 3$ S/m at 100 MHz. Calculate α, β, and η_c.

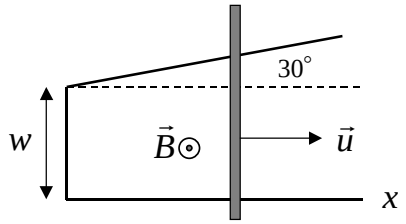
5. An infinite flat boundary between free space and a medium with $\varepsilon_r = 1$ and $\mu_r = 3$ is located in the $z = 0$ plane. The magnetic field intensity in the material is given by $\vec{H}_2 = 2\hat{x} + 5\hat{y} + 5\hat{z}$. Find $\vec{B}_1$.



6. A circular loop TV antenna has an area of 0.01 m^2. When the antenna is oriented for maximum response of a 300 MHz signal, the EMF has a peak value of 20 mV. What is the peak value of $\vec{B}$?

7. An aircraft is attempting to communicate with a submerged submarine. The frequency is 0.5 MHz and the time-averaged power density of the aircraft signal at the ocean surface, just inside of the water, is 12 kW/ m^2 .
(a) If $\varepsilon_r = 70$ and $\sigma = 5$ S/m is the seawater a good conductor at this frequency?
(b) Find the attenuation constant and intrinsic impedance of the seawater.
(c) If the receiver on the submarine requires an electric field intensity of 0.1 μV/m to establish a reliable link what is the maximum depth for communication?

8. A bar slides along two rails with a constant velocity $\vec{u} = u_o \hat{x}$. One of the rails is at a 30 degree angle with respect to the other, as shown below. Find the EMF induced in the circuit if the magnetic flux density is $\vec{B} = B_o \hat{z}$.



9. Two antennas radiate plane waves toward a distant observer. The phasors of the plane waves are $\vec{E}_1(z) = (j\hat{x} + \hat{y})e^{-j\beta z}$ and $\vec{E}_2(z) = (\hat{x} + j\hat{y})e^{-j\beta z}$.
(a) Find the instantaneous (time-varying) total electric field intensity at the observer, $\vec{E}(z,t)$.
(b) Determine the polarization of the wave. Justify your answer.

10. A carbon dioxide laser has an output power of 1000 W. After focusing the radius of the beam is 0.1 mm. If all of the power is contained in the beam and the beam is a plane wave, then find E_o , the amplitude of the electric field in the beam.

11. Find the phasor representing a leftward travelling wave ($-z$ direction) with amplitude 2 V, frequency 1 GHz, phase velocity 1.5×10^8 m/s, and a phase angle of -30° at $z = 0$.